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# EFFECTS OF LEONARDITE ON SOILS AND FORAGE PLANTS

by

Zoheir M. Abouguendia
Robert C. Godwin
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SRC Technical Report No. 180

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SUMMARY

Leonardite is found in large amounts in the coalfields of the Estevan region of southeastern Saskatchewan. The lignite-like material is of low fuel value, but its use as a soil additive has received considerable attention in recent years. Several studies have shown an increase in plant growth and/or improvement in soil properties, including reduction in soil salinity. Most of those studies, however, were carried out under laboratory, growth room or greenhouse conditions and the effects of leonardite under field conditions remained virtually unexplored.

The present study was designed to investigate the effects of several rates (ranging from 0.75 to 3.00 kg/m) of soil-applied leonardite at three sites located near Saskatoon, Saskatchewan.

Soil parameters considered in this study included pH, electrical conductivity, water soluble ions, extractable cations, and available nitrogen, phosphorous, and potassium. The analysis of the data showed no statistically significant change in any of these parameters, with the exception of a decrease in potassium at one site during the first year only.

Plant parameters measured included plant density and/or yield. Again no statistially significant change in plant density or yield were noted. The nutritive value of the plants was not affected at any of the treatment rates em-

ployed.

It was concluded that under field conditions in the Saskatoon region, the Estevan leonardite has no growth stimulating effects or soil conditioning effects, despite beneficial effects reported in the literature. The contrasting effects may be explained in terms of differences in soil characteristics, in amendment properties and rates, and in experimental conditions.

ACKNOWLEDGEMENTS

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# 1 INTRODUCTION

Leonardite is found in large amounts in the Estevan area of southeastern Saskatchewan. The naturally oxidized material is similar in structure to lignite and contains up to 86% humic acids on a moisture-free-basis. The value of leonardite as a fuel is rather low due to oxidation.

The effect of leonardite, as a soil additive, on plant growth has been the subject of several investigations in recent years. Leonardite and leonardite-derived humic acids were shown to stimulate root initiation and to increase root growth (Aitken et al 1964, Freeman and Fowkes 1968, O'Donnell 1973a). Increase in yield and aboveground biomass as a result of leonardite application was also reported (O'Donnell 1973a, Freeman 1969, Duplessis and MacKenzie 1983). Growth promotion was attributed to auxin-like activity, increase in nutrient availability, or to general improvement in physical and chemical characteristics of the soil.

Saeed (1976), Safaya and Kollman (1976), Safaya and Wali (1979) studied growth and nutrient relations of a grass-legume mixture on sodic coal spoils, as affected by leonardite application. Leonardite reduced Na content in yellow sweetclover (Melilotus officinale) and increased its growth, but caused a reverse effect on northern wheatgrass (Agropyron dasystachyum). It also reduced K and Zn concentration in wheatgrass and Cu and Fe in sweetclover.

Abouguendia and Godwin (1983) observed increase in the emergence rate of grass seedlings grown in the laboratory on sodic coal spoils, but growth was unaffected.

Few studies have been conducted on the effect of leonardite on soil properties. Addition of leonardite resulted in a decrease in the phosphorous diffusion coefficient (Harrel and Saeed 1977). This reduction was attributed to the higher sorption capacity of leonardite than that of the soil. However, Duplessis and MacKenzie (1983) found that phosphorous mobility in the soil was not affected by leonardite application and Safaya and Wali (1979) reported an increase in phosphorous availability.

Laboratory experiments conducted by O'Donnell (1973b) at the Saskatchewan Research Council showed that leonardite addition to saline and alkaline soils resulted in lower electrical conductivity, reduced SAR and lowered the water-soluble $Na^{+}$, $Cl^{-}$, and $Ca^{++}$ concentration in the soil. Dhawan and Mahajan (1964) used low-grade coal as an additive for reclamation of saline and alkaline soils. Substantial reduction in total soluble salts up to a 90 cm depth was recorded. Safaya and Wali (1979) reported that leonardite resulted in lowering of the pH of sodic coal spoils by 0.2-0.3 units.

Recent work (George 1985) showed greater root development of canola plants growing from leonardite-coated seeds than those from untreated seeds.

This study is concerned with the effect of various rates of leonardite applications to three saline soils on plant density and yield, and selected soil properties.

## 2 METHODS AND MATERIAL

The effect of soil applied leonardite was studied at three sites (Floral, Buffer Lake, and Rosthern) near Saskatoon, Saskatchewan (Figure 1). The experimental design and field plans are shown in Appendices A.1 and A.2. A completely randomized design with five replicates was employed. Soil characteristics of the experimental sites are given in Table 1.

At the Floral site, leonardite was incorporated into the top 15 cm of the soil at three rates: 1, 2 and 3 $kg/m^2$ prior to seeding. Control plots, receiving no leonardite, were also included in the design. Two perennial grass species, slender wheatgrass (Agropyron trachycaulum) and western wheatgrass (A. smithii), were seeded on May 10, 1984, using a 4-row plot drill. Slender wheatgrass (Revenue) seed was obtained from commerical sources in Saskatoon, while western wheatgrass (Walsh) seed was obtained from Agriculture Canada Research Station, Lethbridge, Alberta. Seeding rate was 9.9 and 14.9 kg/ha for slender wheatgrass and western wheatgrass, respectively.

Similar experiments were carried out at the other two sites in the spring of 1985, with the exception that yellow sweetclover was used in place of western wheatgrass and the leonardite application rates were changed to 0.75, 1.5 and 3.0 $kg/m^2$.

Leonardite was obtained from the Utility Mine (M & S

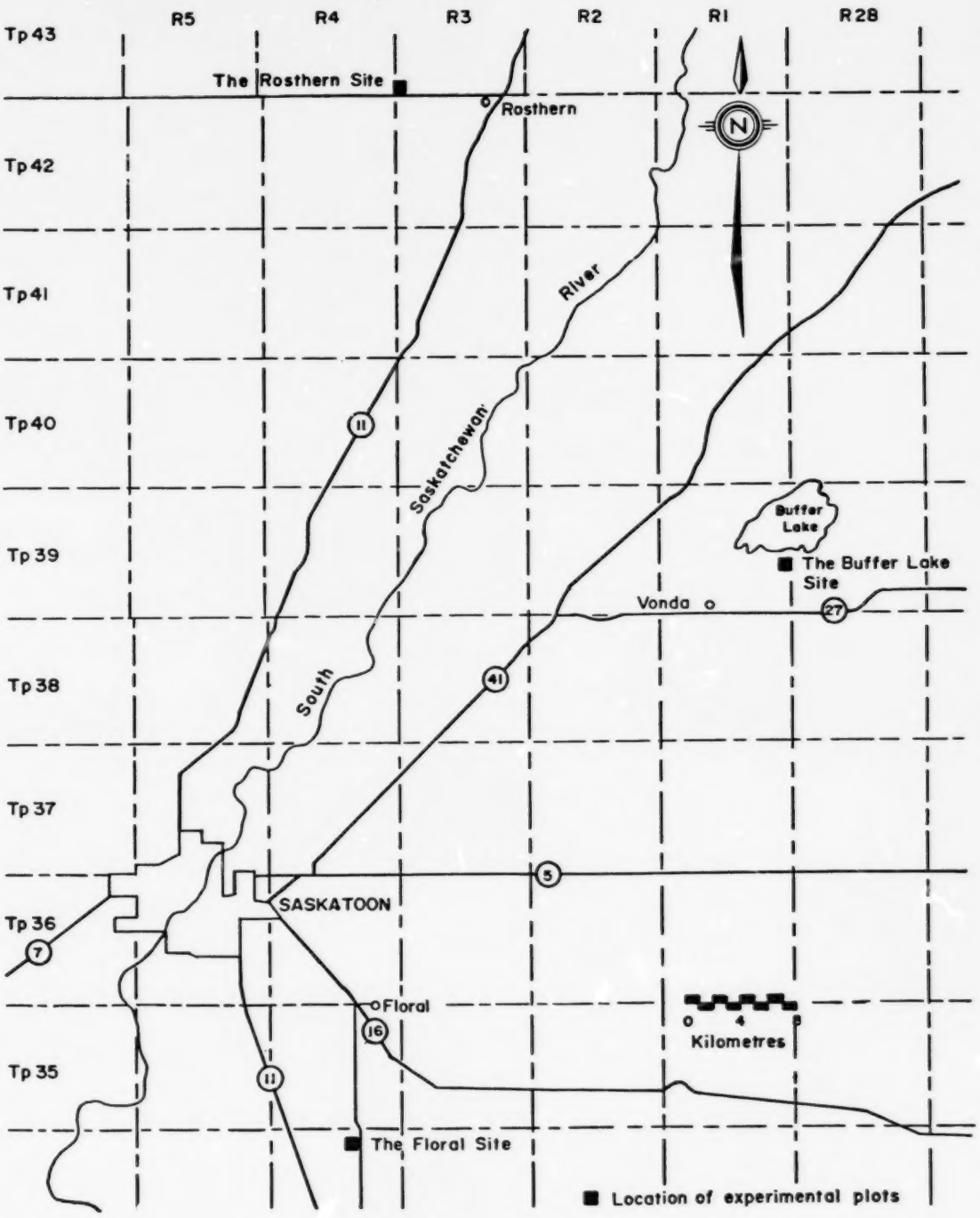


Figure 1. Location of the Experimental Plots.

Table 1. Soil Characteristics for the Experimental Sites (1985 Data).

| Site | Texture | Percent Saturation | Electrical Conductivity (mS/cm) | pH | SAR |
|---|---|---|---|---|---|
| Floral | loam | 45.4 | 7.1 | 8.1 | 5 |
| Buffer Lake | clay loam | 67.1 | 8.2 | 8.1 | 11 |
| Rosthern | loam | 70.0 | 7.7 | 7.6 | 7.6 |

Coal Ltd.), near Estevan. The properties of leonardite are given in Appendix A.3.

Plant density was evaluated along the middle two rows using at least two 0.5 m row segments randomly located in each replicate. Soil samples were obtained at the end of the growing season and were analyzed for the following parameters:

- electrical conductivity
- pH
- sodium adsorption ratio
- water soluble $Na^{+}$, $Ca^{++}$, $Mg^{++}$, $K^{+}$, $Cl^{-}$, and $SO^{--}$.

The results of the 1984 field investigations were included in Abouguendia and Godwin (1985) and only a summary is included in this report.

Chemical analysis was conducted by the Saskatchewan Research Council Analytical Laboratories, and Saskatchewan Soil Testing Laboratory. The data was subjected to analysis of variance.

# 3 RESULTS AND DISCUSSION

## 3.1 1984 Results

The 1984 data showed that leonardite application has resulted in a slight reduction in soil pH, electrical conductivity, and sodium adsorption ratio (SAR). The trend was more apparent in the top 0-15 cm than in the 15-30 cm soil layer. The reduction in salinity was largest in the plots receiving the highest application rate. Similar trends were observed for all major ions determined (except $Ca^{++}$), exchangeable cations, and available nitrogen, phosphorous, and potassium. However, none of these changes were statistically significant, with the exception of potassium.

Heavy application of leonardite actually depressed forage yield. This was attributed to the noted reduction in the level of available inorganic nitrogen in the soil. The plots receiving the lowest leonardite application rate produced 16% greater yield than the untreated plots. This increase, however, was not statistically significant. The nutritional value of the plant material harvested was not affected by any of the treatments.

Detailed data for the 1984 season can be found in Abouguendia and Godwin (1985).

## 3.2 1985 Results

The detailed 1985 soils data are given in Appendix B, while the plant density data are presented in Appendix C. A

summary of the data appears in Tables 2 to 5. Statistical analysis of the soils data (Appendix B.3) showed no significant changes in soil properties evaluated with any of the leonardite application rates. Also, no significant change in plant density data resulted from the leonardite treatments (Appendix C.2). A visual evaluation of the plant vigour towards the end of the growing season showed no apparent differences between treatments. Therefore, no attempt was made to sample the plots for yield determination in 1985.

The literature reviewed in Section 1 indicated that leonardite stimulated plant growth and/or improved soil characteristics. Most of those studies were performed under laboratory or greenhouse conditions. In the present field study, no significant beneficial effects were found. The lack of response to leonardite application under field conditions in this study is difficult to explain, but may be attributed to several factors. Lee and Bartlett (1976) found that application of humic acid to a soil low in organic matter gave the greatest growth response in comparison to soils that are rich in organic matter. The organic matter content of the soils used in this study is probably quite high. This could, also, explain the greater beneficial response when leonardite was applied to non-soil material such as coal spoils (Safaya and Kollman 1976), or to sandy soils (Duplessis and MacKenzie 1983).

Poapst et al (1970) demonstrated differences among spe-

Table 2. Summary of the Results of the Soil Chemical Analysis for the Rosthern Site - 1985.

| Treatments | General Parameters | | | | Ions in Saturation Extract (µg/mL) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent Saturation | pH | Electrical Conductivity (mS/cm) | SAR* | $Na^+$ | $Ca^{++}$ | $Mg^{++}$ | $K^+$ | $Cl^-$ | $SO_4^{--}$ |
| Control | | | | | | | | | | |
| - Mean** | 70.3 | 7.9 | 7.7 | 7.6 | 1037 | 504 | 556 | 20 | 50 | 5430 |
| - Standard Error | 0.92 | 0.05 | 0.35 | 0.4 | 77 | 6.5 | 31 | 2.2 | 5 | 279 |
| Leonardite (L) | | | | | | | | | | |
| L1 (0.75 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 69.0 | 7.9 | 7.6 | 7.8 | 1043 | 508 | 520 | 25 | 66 | 5310 |
| - Standard Error | 1.2 | 0.07 | 0.3 | 0.5 | 73 | 6.1 | 21 | 3.5 | 8 | 207 |
| L2 (1.50 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 47.5 | 7.8 | 7.0 | 6.3 | 858 | 512 | 520 | 25 | 49 | 5060 |
| - Standard Error | 0.88 | 0.04 | 0.45 | 0.7 | 108 | 5.3 | 39 | 2.9 | 8 | 342 |
| L3 (3.0 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 69.7 | 7.8 | 7.7 | 7.7 | 1049 | 496 | 540 | 29 | 60 | 5560 |
| - Standard Error | 0.99 | 0.05 | 0.3 | 0.5 | 71 | 6.5 | 16 | 3.4 | 7 | 280 |

* SAR = Sodium Adsorption Ratio

** Means of 10 observations (detailed data are given in Appendix B.1).

Table 3. Summary of the Results of the Soil Chemical Analysis for the Buffer Lake Site - 1985.

| Treatments | General Parameters | | | | Ions in Saturation Extract (µg/mL) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent Saturation | pH | Electrical Conductivity (mS/cm) | SAR* | $Na^+$ | $Ca^{++}$ | $Mg^{++}$ | $K^+$ | $Cl^-$ | $SO_4^{--}$ |
| Control | | | | | | | | | | |
| - Mean** | 67.1 | 8.1 | 8.3 | 11.0 | 1372 | 476 | 401 | 24 | 175 | 5090 |
| - Standard Error | 0.9 | 0.04 | 0.67 | 1.0 | 157 | 7.2 | 41 | 2.5 | 18 | 480 |
| Leonardite (L) | | | | | | | | | | |
| L1 (0.75 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 68.2 | 8.1 | 7.7 | 10.9 | 1281 | 429 | 351 | 23 | 178 | 4611 |
| - Standard Error | 1.54 | 0.04 | 0.78 | 0.9 | 154 | 31 | 47 | 1.6 | 23 | 572 |
| L2 (1.50 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 65.4 | 8.0 | 7.3 | 9.9 | 1160 | 444 | 353 | 23 | 138 | 4452 |
| - Standard Error | 0.78 | 0.04 | 0.77 | 0.8 | 142 | 32 | 52 | 1.5 | 12 | 554 |
| L3 (3.0 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 67.4 | 7.9 | 8.2 | 11.6 | 1387 | 459 | 365 | 23 | 188 | 4940 |
| - Standard Error | 0.99 | 0.05 | 0.63 | 1.1 | 153 | 13 | 9 | 1.5 | 16 | 420 |

* SAR = Sodium Adsorption Ratio

** Means of 10 observations (detailed data are given in Appendix B.1).

Table 4. Summary of the Results of the Soil Chemical Analysis for the Floral Site - 1985.

| Treatments | General Parameters | | | | Ions in Saturation Extract (ug/mL) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent Saturation | pH | Electrical Conductivity (mS/cm) | SAR* | $Na^{+}$ | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | $Cl^{-}$ | $SO_4^{--}$ |
| Control | | | | | | | | | | |
| - Mean** | 45.4 | 8.2 | 7.2 | 5.0 | 545 | 504 | 646 | 54 | 56 | 5440 |
| - Standard Error | 0.56 | 0.03 | 0.38 | 0.39 | 83 | 6.5 | 82 | 2.6 | 18 | 419 |
| Leonardite (L) | | | | | | | | | | |
| L1 (1 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 46.6 | 8.2 | 7.2 | 5.2 | 782 | 492 | 712 | 53 | 55 | 5380 |
| - Standard Error | 0.63 | 0.21 | 0.39 | 0.5 | 83 | 6.1 | 62 | 2.8 | 19 | 333 |
| L2 (1.5 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 46.7 | 8.0 | 7.7 | 5.6 | 830 | 492 | 768 | 52 | 62 | 5740 |
| - Standard Error | 0.61 | 0.01 | 0.49 | 0.6 | 107 | 8.5 | 83 | 2.9 | 16 | 559 |
| L3 (2.0 kg/$m^2$) | | | | | | | | | | |
| - Mean** | 47.3 | 8.0 | 8.5 | 6.4 | 1062 | 500 | 856 | 55 | 87 | 5460 |
| - Standard Error | 0.99 | 0.01 | 0.85 | 0.9 | 183 | 6.7 | 106 | 3.8 | 21 | 706 |

* SAR = Sodium Adsorption Ratio

** Means of 10 observations (detailed data are given in Appendix B.1).

Table 5. Summary of the Plant Density Data - 1985.

| Location | Date | Species Seeded | Species Counted | Number of Plants per Metre of Row* | | | |
|---|---|---|---|---|---|---|---|
| | | | | L1 | L2 | L3 | C |
| Floral | June 13 | Slender wheatgrass | Total grasses | 10.8** (2.98) | 12.0 (2.4) | 12.0 (2.7) | 15.0 (3.23) |
| | | Western wheatgrass | Total grasses | 17.8 (1.97) | 13.6 (3.18) | 25.6 (3.95) | 11.2 (2.46) |
| | July 23 | Slender wheatgrass | Slender wheatgrass | 3.4 (1.73) | 2.8 (1.58) | 4.6 (1.6) | 4.0 (2.05) |
| | | Western wheatgrass | Western wheatgrass | 0.8 (1.35) | 4.4 (2.16) | 2.6 (2.05) | 7.2 (1.68) |
| Buffer Lake | July 3 | Slender wheatgrass | Total wheatgrasses | 2.0 (0) | 1.6 (0.95) | 2.0 (1) | 2.8 (1.35) |
| | | Sweetclover | Sweetclover | 2.6 (1.4) | 1.2 (0.65) | 1.4 (1.24) | 1.8 (1.05) |
| | July 22 | Slender wheatgrass | Total wheatgrasses | 2.8 (1.47) | 1.6 (1.05) | 2.6 (1.05) | 2.8 (1.25) |
| | | Sweetclover | Sweetclover | 2.6 (1.45) | 1.6 (1.24) | 4.8 (1.82) | 3.0 (1.1) |
| Rosthern | July 3 | Slender wheatgrass | Total wheatgrasses | 3.2 (2.1) | 2.0 (1) | 1.0 (0) | 2.4 (1.38) |
| | | Sweetclover | Sweetclover | 0.8 (0.9) | 0.5 (0.9) | 0.6 (0.7) | 0.8 (0.65) |
| | July 24 | Slender wheatgrass | Total wheatgrasses | 5.6 (2.25) | 4.6 (2.2) | 3.4 (1.58) | 5.2 (1.89) |
| | | Sweetclover | Sweetclover | 1.0 (0.84) | 0.8 (0.9) | 0.4 (0.7) | 1.2 (0.9) |

*Leonardite application rates ($kg/m^2$)

| | Floral | Buffer Lake | Rosthern |
|---|---|---|---|
| L1 | 1 | 0.75 | 0.75 |
| L2 | 2 | 1.50 | 1.50 |
| L3 | 3 | 3.00 | 3.00 |
| C | 0 | 0 | 0 |

**Means of five estimates with standard errors in brackets (detailed data are shown in Appendix C.1).

cies in optimum concentration of humic acid for the highest stimulating effects. This could explain the slight yield depression resulting from the heavier leonardite application rates in 1985.

Different humic acid substances appear to produce different effects on plant growth (Lee and Bartlett 1976). In this study, only one source of leonardite, i.e. Estevan leonardite, was used. Some of the reported benefits resulted from North Dakota (Duplessis and MacKenzie 1983) or New Mexico (O'Donnell 1970, 1973b) leonardites.

Duplessis and MacKenzie (1983) attributed the increase in corn yield accompanying leonardite application partly to increase in the level of available phosphorous. In the present study, the 1984 data showed no significant increase in available phosphorous.

The significant reduction in soil salinity reported by Dhawan and Mahajan (1964) was obtained under irrigation (additional 375 mm of water during the growing season) conditions. The present study was conducted under dryland farming conditions with mean annual precipitation between 350 and 400 mm.

# 4 CONCLUSIONS

The application of Estevan leonardite to three agricultural soils in the Saskatoon region showed no statistically significant effects on forage yield, plant density, or soil properties. It can be concluded, therefore, that under field conditions, the Estevan leonardite, applied at the rates employed in this study (0.75 to 3.00 $kg/m^2$), has no growth-stimulating effects or soil conditioning effects, despite beneficial changes reported for leonardite from other sources (e.g. North Dakota) and for other types of substrates (e.g. sandy soils, coal spoils). These contrasting effects may be explained in terms of differences in soil characteristics, amendment properties and rates, and experimental conditions.

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# APPENDIX A

Appendix A.1 Field Plan - Floral Site.

| | |
|---|---|
| 1 SW/L2 | 21 WW/C |
| 2 WW/L1 | 22 SW/L2 |
| 3 SW/L3 | 23 SW/L3 |
| 4 SW/C | 24 WW/L3 |
| 5 WW/C | 25 SW/L2 |
| 6 WW/L2 | 26 SW/L1 |
| 7 SW/L2 | 27 WW/L2 |
| 8 WW/L1 | 28 WW/C |
| 9 WW/L3 | 29 SW/L3 |
| 10 SW/L1 | 30 WW/C |
| 11 WW/L2 | 31 SW/L1 |
| 12 WW/L1 | 32 SW/C |
| 13 SW/L3 | 33 WW/L2 |
| 14 SW/C | 34 WW/L3 |
| 15 WW/C | 35 SW/L1 |
| 16 WW/L2 | 36 SW/L2 |
| 17 SW/C | 37 WW/L1 |
| 18 WW/L3 | 38 WW/L3 |
| 19 WW/L1 | 39 SW/L1 |
| 20 SW/L3 | 40 SW/C |

Plot Plan for the Floral Site

Species

SW Slender Wheatgrass (Revenue)
WW Western Wheatgrass (Walsh)

Treatments

C Control
L1 Leonardite at 1 kg/$m^2$
L2 Leonardite at 2 kg/$m^2$
L3 Leonardite at 3 kg/$m^2$

Plot Size: 1.2 m x 9 m
Buffer Zone: 1.2 m between plots
Row Spacing: 30 cm
Design: Completely randomized with five replicates.
Date Seeded: May 10, 1984

Appendix A.2 Field Plan - Buffer Lake and Rosthern Sites.

| | |
|---|---|
| 1 SW/L2 | 21 SC/C |
| 2 SC/L1 | 22 SW/L2 |
| 3 SW/L3 | 23 SW/L3 |
| 4 SW/C | 24 SC/L3 |
| 5 SC/C | 25 SW/L2 |
| 6 SC/L2 | 26 SW/L1 |
| 7 SW/L2 | 27 SC/L2 |
| 8 SC/L1 | 28 SC/C |
| 9 SC/L3 | 29 SW/L3 |
| 10 SW/L1 | 30 SC/C |
| 11 SC/L2 | 31 SW/L1 |
| 12 SC/L1 | 32 SW/C |
| 13 SW/L3 | 33 SC/L2 |
| 14 SW/C | 34 SC/L3 |
| 15 SC/C | 35 SW/L1 |
| 16 SC/L2 | 36 SW/L2 |
| 17 SW/C | 37 SC/L1 |
| 18 SC/L3 | 38 SC/L3 |
| 19 SC/L1 | 39 SW/L1 |
| 20 SW/L3 | 40 SW/C |

Plot Plan for the Buffer Lake and Rosthern Sites

Species

SW Slender Wheatgrass (Revenue)
SC Yellow Sweetclover

Treatments

C Control
L1 Leonardite at 0.75 kg/$m^2$
L2 Leonardite at 1.50 kg/$m^2$
L3 Leonardite at 3.00 kg/$m^2$

Plot Size: 1.2 m x 9 m
Buffer Zone: 1.2 m between plots
Row Spacing: 30 cm
Design: Completely randomized with five replicates.
Date Seeded:
Buffer Lake - May 24, 1985
Rosthern - June 5, 1985

Appendix A.3 Results of the Leonardite Analysis.

| | Unit | Value |
|---|---|---|
| MAJOR CONSTITUENTS | | |
| C, dry | % | 42 |
| Ca, by A.A. | % | 2.6 |
| Hydrogen, dry | % | 2.5 |
| K, by A.A. | % | 0.14 |
| Mg, by A.A. | % | 0.48 |
| N, dry | % | 0.1 |
| Na, by A.A. | % | 0.16 |
| O, dry | % | 7.7 |
| S, dry | % | 0.27 |
| TRACE CONSTITUENTS | | |
| $SO_3$, calc'd | % | 0.68 |
| TRACE METALS | | |
| Al, by A.A. | % | 3.4 |
| Fe, by A.A. | % | 0.72 |
| Mn, by A.A. | % | 0.005 |
| Si, by A.A. | % | 6.3 |
| Ti, by A.A. | % | 0.27 |
| PHYSICAL PROPERTIES | | |
| Ash, dry | % | 31.8 |
| Moisture at 105°C | % | 8.71 |
| Saturation | % | 96 |
| SALINITY ANALYSIS | | |
| pH | | 4.2 |
| Conductivity | mS/cm | 2.5 |
| Ions in Saturation Extract: | | |
| $Na^+$ | µg/mL | 260 |
| $Ca^{++}$ | µg/mL | 238 |
| $Mg^{++}$ | µg/mL | 140 |
| $K^+$ | µg/mL | 19 |
| $Cl^-$ | µg/mL | 20 |
| $SO_4^{--}$ | µg/mL | 1500 |
| SAR | µg/mL | 3.3 |

# APPENDIX B

## Appendix B.1 Results of the Soils Chemical Analysis.*

SASKATCHEWAN SOIL TESTING LABORATORY
SALINITY ANALYSIS
***SRC-AEOUGUENDIA***



| Lab # | Client Identification | % Sat | pH | COND. (mS/cm) | IONS IN SATURATION EXTRACT(ug/mL) Na+ | Ca++ | Mg++ | K+ | Cl- | SO4= | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IS-0927 | E902-11-129 | 48 | 8.1 | 9.6 | 1340 | 480 | 920 | 73 | 70 | 7500 | 8.3 |
| IS-0928 | E902-11-130 | 49 | 8.0 | 6.9 | 770 | 480 | 640 | 63 | 29 | 5300 | 5.4 |
| IS-0929 | E902-11-131 | 55 | 7.8 | 8.1 | 1010 | 480 | 720 | 45 | 34 | 6100 | 6.8 |
| IS-0930 | E902-11-132 | 46 | 8.1 | 6.1 | 610 | 480 | 520 | 51 | 19 | 4500 | 4.6 |
| IS-0931 | E902-11-133 | 43 | 8.1 | 6.5 | 730 | 520 | 520 | 49 | 31 | 4900 | 5.4 |
| IS-0932 | E902-11-134 | 45 | 7.8 | 4.9 | 320 | 560 | 440 | 50 | 11 | 3800 | 2.5 |
| IS-0933 | E902-11-135 | 46 | 7.8 | 6.0 | 540 | 480 | 600 | 54 | 21 | 4500 | 3.9 |
| IS-0934 | E902-11-136 | 46 | 7.7 | 5.7 | 430 | 480 | 560 | 65 | 20 | 4300 | 3.2 |
| IS-0935 | E902-11-137 | 45 | 7.7 | 5.5 | 420 | 520 | 520 | 64 | 19 | 4100 | 3.1 |
| IS-0936 | E902-11-138 | 46 | 8.0 | 6.8 | 800 | 480 | 560 | 48 | 33 | 4900 | 5.9 |
| IS-0937 | E902-11-139 | 48 | 7.7 | 6.4 | 650 | 480 | 600 | 48 | 47 | 4700 | 4.7 |
| IS-0938 | E902-11-140 | 47 | 7.9 | 4.7 | 290 | 520 | 400 | 49 | 15 | 3500 | 2.3 |
| IS-0939 | E902-11-141 | 45 | 7.6 | 6.0 | 540 | 520 | 520 | 52 | 37 | 4100 | 4.0 |
| IS-0940 | E902-11-142 | 47 | 8.0 | 8.0 | 1010 | 480 | 720 | 51 | 159 | 5900 | 6.8 |
| IS-0941 | E902-11-143 | 45 | 8.1 | 5.3 | 420 | 520 | 440 | 62 | 27 | 3900 | 3.3 |
| IS-0942 | E902-11-144 | 45 | 8.0 | 5.7 | 590 | 480 | 480 | 58 | 22 | 3900 | 4.6 |
| IS-0943 | E902-11-145 | 48 | 8.1 | 5.3 | 430 | 520 | 440 | 56 | 20 | 4000 | 3.4 |
| IS-0944 | E902-11-146 | 49 | 8.0 | 5.3 | 400 | 520 | 440 | 67 | 28 | 3900 | 3.1 |
| IS-0945 | E902-11-147 | 48 | 8.1 | 6.8 | 730 | 520 | 600 | 62 | 42 | 5000 | 5.2 |
| IS-0946 | E902-11-148 | 49 | 8.1 | 12.7 | 2050 | 480 | 1200 | 79 | 220 | 9500 | 11.4 |
| IS-0947 | E902-11-149 | 48 | 8.2 | 7.4 | 780 | 520 | 760 | 64 | 23 | 5800 | 5.1 |
| IS-0948 | E902-11-150 | 48 | 8.5 | 11.4 | 1620 | 480 | 1320 | 47 | 134 | 9400 | 8.7 |
| IS-0949 | E902-11-151 | 46 | 8.4 | 11.1 | 1650 | 480 | 1120 | 38 | 139 | 8800 | 9.4 |
| IS-0950 | E902-11-152 | 45 | 8.3 | 12.3 | 1760 | 480 | 1480 | 53 | 155 | 9800 | 9.0 |
| IS-0951 | E902-11-153 | 45 | 8.1 | 8.6 | 1010 | 520 | 920 | 48 | 41 | 6200 | 6.2 |

*NOTE: See Appendix B.2 for cross referencing of the experimental plot numbers.

## Appendix B.1 (Continued)

SASKATCHEWAN SOIL TESTING LABORATORY

Date: 10-09-85 SALINITY ANALYSIS Page: 2 of 5

$SRC-ASOUG03=IS-0927/1046 ***SRC-ASOUGUENDIA***

| Lab # | Client Identification | Z Sat | pH | COND. (mS/cm) | IONS IN SATURATION EXTRACT(ug/mL) Na+ | Ca++ | Mg++ | K+ | Cl- | SO4= | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IS-0952 | E902-11-154 | 44 | 8.2 | 8.8 | 940 | 520 | 960 | 59 | 135 | 6700 | 5.6 |
| IS-0953 | E902-11-155 | 48 | 8.1 | 8.9 | 1040 | 480 | 920 | 59 | 59 | 6900 | 6.4 |
| IS-0954 | E902-11-156 | 44 | 8.2 | 8.3 | 880 | 480 | 880 | 65 | 49 | 6400 | 5.5 |
| IS-0955 | E902-11-157 | 45 | 8.1 | 8.9 | 1000 | 480 | 960 | 58 | 71 | 6800 | 6.1 |
| IS-0956 | E902-11-158 | 44 | 8.2 | 10.6 | 1280 | 480 | 1240 | 53 | 167 | 8400 | 7.0 |
| IS-0957 | E902-11-159 | 43 | 8.1 | 8.1 | 910 | 480 | 800 | 40 | 60 | 6000 | 5.9 |
| IS-0958 | E902-11-160 | 44 | 8.2 | 7.2 | 720 | 520 | 720 | 39 | 39 | 5300 | 4.8 |
| IS-0959 | E902-11-161 | 44 | 8.1 | 7.3 | 800 | 480 | 720 | 45 | 52 | 5300 | 5.4 |
| IS-0960 | E902-11-162 | 47 | 8.0 | 7.5 | 770 | 520 | 760 | 51 | 67 | 5400 | 5.0 |
| IS-0961 | E902-11-163 | 46 | 8.2 | 7.3 | 740 | 480 | 760 | 44 | 55 | 5300 | 4.9 |
| IS-0962 | E902-11-164 | 50 | 8.1 | 7.1 | 690 | 480 | 760 | 42 | 162 | 5200 | 4.6 |
| IS-0963 | E902-11-165 | 48 | 8.3 | 9.5 | 1090 | 480 | 1040 | 51 | 210 | 7000 | 6.4 |
| IS-0964 | E902-11-166 | 47 | 8.1 | 8.5 | 1020 | 520 | 840 | 46 | 104 | 6100 | 6.4 |
| IS-0965 | E902-11-167 | 49 | 8.2 | 8.9 | 1120 | 480 | 800 | 46 | 82 | 5800 | 7.3 |
| IS-0966 | E902-11-168 | 45 | 8.3 | 6.0 | 590 | 520 | 520 | 47 | 28 | 4400 | 4.4 |
| IS-0967 | E902-11-169 | 60 | 7.9 | 5.8 | 730 | 520 | 288 | 27 | 100 | 3400 | 6.4 |
| IS-0968 | E902-11-170 | 63 | 7.8 | 3.0 | 440 | 180 | 92 | 29 | 42 | 1010 | 6.7 |
| IS-0969 | E902-11-171 | 64 | 7.9 | 6.5 | 1020 | 480 | 268 | 25 | 143 | 3900 | 9.3 |
| IS-0970 | E902-11-172 | 62 | 7.9 | 4.7 | 580 | 440 | 228 | 30 | 46 | 2700 | 5.6 |
| IS-0971 | E902-11-173 | 64 | 7.9 | 6.4 | 910 | 520 | 284 | 41 | 194 | 3500 | 8.0 |
| IS-0972 | E902-11-174 | 67 | 7.8 | 5.6 | 810 | 440 | 220 | 30 | 72 | 3200 | 7.9 |
| IS-0973 | E902-11-175 | 64 | 7.9 | 3.2 | 480 | 164 | 100 | 28 | 152 | 1020 | 7.3 |
| IS-0974 | E902-11-176 | 66 | 8.0 | 5.7 | 920 | 344 | 208 | 26 | 173 | 3000 | 9.7 |
| IS-0975 | E902-11-177 | 63 | 7.6 | 5.9 | 880 | 440 | 236 | 31 | 138 | 3300 | 8.4 |
| IS-0976 | E902-11-178 | 67 | 8.0 | 6.7 | 1020 | 480 | 288 | 32 | 180 | 3800 | 9.1 |

Comment:

## Appendix B.1 (Continued)

SASKATCHEWAN SOIL TESTING LABORATORY

Date: 10-09-85 — SALINITY ANALYSIS — Page: 3 of 5

$SRC-AB0UG09*IS-0977 1046 — ***SRC-AB0UGUENDIA***

| Lab # | Client Identification | % Sat | pH | COND. (mS/cm) | IONS IN SATURATION EXTRACT(ug/mL) Na+ | Ca++ | Mg++ | K+ | Cl- | SO4= | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IS-0977 | E902-11-179 | 65 | 8.0 | 7.0 | 1100 | 520 | 288 | 27 | 156 | 4200 | 9.6 |
| IS-0978 | E902-11-180 | 68 | 8.1 | 9.9 | 1800 | 480 | 480 | 23 | 320 | 5900 | 13.9 |
| IS-0979 | E902-11-181 | 64 | 7.9 | 9.2 | 1680 | 480 | 400 | 27 | 250 | 5400 | 13.7 |
| IS-0980 | E902-11-182 | 65 | 8.1 | 8.6 | 1500 | 480 | 376 | 22 | 180 | 5200 | 12.5 |
| IS-0981 | E902-11-183 | 71 | 8.2 | 9.2 | 1570 | 480 | 480 | 25 | 210 | 5800 | 12.1 |
| IS-0982 | E902-11-184 | 69 | 8.1 | 9.7 | 1800 | 480 | 440 | 19 | 170 | 6000 | 14.3 |
| IS-0983 | E902-11-185 | 68 | 8.2 | 12.0 | 2380 | 480 | 520 | 25 | 220 | 7700 | 17.9 |
| IS-0984 | E902-11-186 | 69 | 8.1 | 10.3 | 2040 | 440 | 364 | 22 | 220 | 6200 | 17.4 |
| IS-0985 | E902-11-187 | 63 | 8.0 | 6.1 | 930 | 440 | 232 | 23 | 164 | 3500 | 8.9 |
| IS-0986 | E902-11-188 | 68 | 7.9 | 4.9 | 710 | 348 | 188 | 23 | 118 | 2700 | 7.6 |
| IS-0987 | E902-11-189 | 71 | 8.1 | 7.0 | 1120 | 480 | 312 | 14 | 132 | 4400 | 9.6 |
| IS-0988 | E902-11-190 | 65 | 7.9 | 6.2 | 910 | 440 | 308 | 18 | 96 | 4000 | 8.1 |
| IS-0989 | E902-11-191 | 70 | 8.1 | 8.6 | 1470 | 480 | 400 | 17 | 240 | 5300 | 12.0 |
| IS-0990 | E902-11-192 | 69 | 8.0 | 11.4 | 2140 | 480 | 520 | 20 | 230 | 7000 | 16.1 |
| IS-0991 | E902-11-193 | 65 | 8.1 | 7.9 | 1350 | 480 | 320 | 17 | 134 | 4900 | 11.7 |
| IS-0992 | E902-11-194 | 67 | 8.1 | 7.9 | 1330 | 480 | 324 | 19 | 143 | 4900 | 11.5 |
| IS-0993 | E902-11-195 | 66 | 7.9 | 7.3 | 1130 | 480 | 324 | 20 | 135 | 4400 | 9.8 |
| IS-0994 | E902-11-196 | 68 | 8.1 | 8.7 | 1430 | 480 | 440 | 20 | 220 | 5400 | 11.3 |
| IS-0995 | E902-11-197 | 65 | 7.9 | 7.4 | 1110 | 480 | 376 | 19 | 220 | 4500 | 9.2 |
| IS-0996 | E902-11-198 | 68 | 8.2 | 9.9 | 1690 | 480 | 560 | 15 | 210 | 6400 | 12.4 |
| IS-0997 | E902-11-199 | 68 | 8.1 | 8.5 | 1360 | 480 | 440 | 16 | 210 | 5300 | 10.8 |
| IS-0998 | E902-11-200 | 67 | 8.2 | 9.4 | 1520 | 480 | 560 | 17 | 210 | 6100 | 11.2 |
| IS-0999 | E902-11-201 | 65 | 8.1 | 9.5 | 1470 | 480 | 640 | 22 | 176 | 6300 | 10.3 |
| IS-1000 | E902-11-202 | 72 | 8.0 | 8.1 | 1180 | 480 | 520 | 18 | 125 | 5400 | 8.9 |
| IS-1001 | E902-11-203 | 68 | 8.0 | 8.4 | 1260 | 520 | 520 | 21 | 128 | 5600 | 9.3 |

Comments:

## Appendix B.1 (Continued)

SASKATCHEWAN SOIL TESTING LABORATORY
SALINITY ANALYSIS
***SRC-ABOUGUENDIA***

Date: 10-09-85
$SRC-ABOUGUENDIA*IS-1027/1046

Page: 4 of 5

| Lab # | Client Identification | % Sat | pH | COND. ((mS/cm)) | IONS IN SATURATION EXTRACT(mg/mL) Na+ | Ca++ | Mg++ | K+ | Cl- | SO4= | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IS-1002 | E902-11-204 | 68 | 8.1 | 10.5 | 1820 | 440 | 600 | 19 | 188 | 7100 | 13.3 |
| IS-1003 | E902-11-205 | 72 | 8.2 | 11.4 | 2130 | 440 | 560 | 26 | 230 | 7400 | 15.9 |
| IS-1004 | E902-11-206 | 70 | 8.1 | 9.3 | 1640 | 480 | 376 | 29 | 200 | 5700 | 13.6 |
| IS-1005 | E902-11-207 | 80 | 8.2 | 9.1 | 1620 | 480 | 368 | 19 | 194 | 5700 | 13.5 |
| IS-1006 | E902-11-208 | 67 | 8.0 | 6.6 | 1020 | 440 | 252 | 26 | 129 | 3700 | 9.6 |
| IS-1007 | E902-11-209 | 61 | 7.6 | 5.0 | 430 | 520 | 384 | 29 | 23 | 2500 | 3.5 |
| IS-1008 | E902-11-210 | 63 | 7.5 | 6.8 | 870 | 520 | 480 | 16 | 45 | 4900 | 6.6 |
| IS-1009 | E902-11-211 | 67 | 7.8 | 6.8 | 870 | 480 | 480 | 17 | 30 | 5200 | 6.7 |
| IS-1010 | E902-11-212 | 70 | 7.9 | 8.2 | 1210 | 480 | 600 | 22 | 54 | 6100 | 8.7 |
| IS-1011 | E902-11-213 | 69 | 7.9 | 6.2 | 700 | 520 | 440 | 25 | 29 | 4400 | 5.5 |
| IS-1012 | E902-11-214 | 69 | 7.9 | 5.4 | 510 | 520 | 440 | 28 | 23 | 3900 | 4.0 |
| IS-1013 | E902-11-215 | 70 | 7.9 | 6.5 | 710 | 520 | 520 | 36 | 25 | 4700 | 5.3 |
| IS-1014 | E902-11-216 | 73 | 7.9 | 7.1 | 900 | 520 | 520 | 38 | 48 | 4900 | 6.7 |
| IS-1015 | E902-11-217 | 72 | 7.9 | 7.8 | 1120 | 520 | 560 | 37 | 74 | 5600 | 8.1 |
| IS-1016 | E902-11-218 | 74 | 7.8 | 8.0 | 1180 | 480 | 560 | 41 | 99 | 5700 | 8.7 |
| IS-1017 | E902-11-219 | 71 | 7.8 | 8.8 | 1350 | 480 | 600 | 31 | 104 | 6100 | 9.7 |
| IS-1018 | E902-11-220 | 73 | 7.9 | 7.3 | 990 | 520 | 520 | 31 | 51 | 5100 | 7.3 |
| IS-1019 | E902-11-221 | 73 | 7.8 | 7.3 | 970 | 480 | 520 | 36 | 66 | 5000 | 7.3 |
| IS-1020 | E902-11-222 | 76 | 7.9 | 7.6 | 1070 | 480 | 520 | 28 | 69 | 5200 | 8.1 |
| IS-1021 | E902-11-223 | 72 | 8.1 | 7.1 | 960 | 480 | 520 | 21 | 59 | 5000 | 7.2 |
| IS-1022 | E902-11-224 | 69 | 7.9 | 6.2 | 710 | 520 | 440 | 37 | 42 | 4400 | 5.5 |
| IS-1023 | E902-11-225 | 74 | 8.0 | 7.2 | 920 | 520 | 520 | 32 | 46 | 4900 | 6.8 |
| IS-1024 | E902-11-226 | 70 | 7.9 | 7.4 | 970 | 480 | 560 | 41 | 70 | 5100 | 7.1 |
| IS-1025 | E902-11-227 | 69 | 8.0 | 8.6 | 1260 | 480 | 600 | 38 | 97 | 5900 | 9.1 |
| IS-1026 | E902-11-228 | 69 | 7.9 | 6.9 | 850 | 520 | 520 | 44 | 62 | 4600 | 6.3 |

Comments:

## Appendix B.1 (Continued)

Date: 10-09-85
$SRC-ABOUG@3#I5-1027/1046

SASKATCHEWAN SOIL TESTING LABORATORY
SALINITY ANALYSIS
***SRC-ABOUGUENDIA***



| Lab # | Client Identification | % Sat | pH | COND. (mS/cm) | IONS IN SATURATION EXTRACT(ug/mL) Na+ | Ca++ | Mg++ | K+ | Cl- | SO4= | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I5-1027 | E902-11-229 | 67 | 7.9 | 9.8 | 1430 | 520 | 760 | 21 | 80 | 6800 | 9.4 |
| I5-1028 | E902-11-230 | 67 | 8.1 | 9.8 | 1490 | 480 | 800 | 18 | 72 | 7100 | 9.3 |
| I5-1029 | E902-11-231 | 66 | 7.9 | 9.2 | 1400 | 480 | 600 | 32 | 92 | 6400 | 10.1 |
| I5-1030 | E902-11-232 | 64 | 8.0 | 9.3 | 1400 | 480 | 640 | 33 | 82 | 6400 | 9.8 |
| I5-1031 | E902-11-233 | 68 | 7.9 | 8.2 | 1150 | 520 | 600 | 28 | 68 | 5800 | 8.2 |
| I5-1032 | E902-11-234 | 68 | 8.0 | 9.6 | 1520 | 480 | 640 | 22 | 81 | 6600 | 10.7 |
| I5-1033 | E902-11-235 | 66 | 7.7 | 6.5 | 690 | 520 | 520 | 17 | 36 | 4700 | 5.1 |
| I5-1034 | E902-11-236 | 70 | 7.8 | 9.2 | 1390 | 480 | 680 | 15 | 52 | 6700 | 9.6 |
| I5-1035 | E902-11-237 | 73 | 7.5 | 6.4 | 730 | 520 | 480 | 19 | 24 | 4600 | 5.6 |
| I5-1036 | E902-11-238 | 69 | 7.6 | 6.8 | 810 | 520 | 480 | 13 | 41 | 4700 | 6.2 |
| I5-1037 | E902-11-239 | 70 | 7.5 | 6.2 | 690 | 520 | 400 | 15 | 38 | 4200 | 5.5 |
| I5-1038 | E902-11-240 | 69 | 7.7 | 7.1 | 870 | 520 | 520 | 11 | 36 | 5000 | 6.5 |
| I5-1039 | E902-11-241 | 68 | 7.8 | 6.4 | 730 | 520 | 440 | 12 | 44 | 4500 | 5.7 |
| I5-1040 | E902-11-242 | 71 | 7.7 | 8.1 | 1170 | 480 | 520 | 15 | 52 | 5700 | 8.8 |
| I5-1041 | E902-11-243 | 66 | 8.0 | 7.5 | 1020 | 520 | 480 | 18 | 100 | 5200 | 7.8 |
| I5-1042 | E902-11-244 | 66 | 7.9 | 7.1 | 860 | 520 | 480 | 18 | 53 | 5000 | 6.5 |
| I5-1043 | E902-11-245 | 64 | 8.1 | 7.3 | 980 | 520 | 480 | 12 | 35 | 5100 | 7.5 |
| I5-1044 | E902-11-246 | 72 | 8.0 | 7.6 | 1010 | 520 | 520 | 20 | 46 | 5400 | 7.5 |
| I5-1045 | E902-11-247 | 70 | 7.9 | 7.6 | 1020 | 520 | 520 | 16 | 41 | 5500 | 7.6 |
| I5-1046 | E902-11-248 | 67 | 8.1 | 7.6 | 1010 | 520 | 520 | 14 | 35 | 5500 | 7.5 |

Comment:

***End***

Appendix B.2 A Cross Reference to Soil Sample Numbers.

| Floral | | Buffer Lake | | Rosthern | |
|---|---|---|---|---|---|
| Sample Identification Number (1) | Experimental Plot Number (2) | Sample Identification Number (1) | Experimental Plot Number (3) | Sample Identification Number (1) | Experimental Plot Number (3) |
| E-902-11-129 | 1 | E-902-11-169 | 1 | E-902-11-209 | 1 |
| -130 | 2 | -170 | 2 | -210 | 2 |
| -131 | 3 | -171 | 3 | -211 | 3 |
| -132 | 4 | -172 | 4 | -212 | 4 |
| -133 | 5 | -173 | 5 | -213 | 5 |
| -134 | 6 | -174 | 6 | -214 | 6 |
| -135 | 7 | -175 | 7 | -215 | 7 |
| -136 | 8 | -176 | 8 | -216 | 8 |
| -137 | 9 | -177 | 9 | -217 | 9 |
| -138 | 10 | -178 | 10 | -218 | 10 |
| -139 | 11 | -179 | 11 | -219 | 11 |
| -140 | 12 | -180 | 12 | -220 | 12 |
| -141 | 13 | -181 | 13 | -221 | 13 |
| -142 | 14 | -182 | 14 | -222 | 14 |
| -143 | 15 | -183 | 15 | -223 | 15 |
| -144 | 16 | -184 | 16 | -224 | 16 |
| -145 | 17 | -185 | 17 | -225 | 17 |
| -146 | 18 | -186 | 18 | -226 | 18 |
| -147 | 19 | -187 | 19 | -227 | 19 |
| -148 | 20 | -188 | 20 | -228 | 20 |
| -149 | 21 | -189 | 21 | -229 | 21 |
| -150 | 22 | -190 | 22 | -230 | 22 |
| -151 | 23 | -191 | 23 | -231 | 23 |
| -152 | 24 | -192 | 24 | -232 | 24 |
| -153 | 25 | -193 | 25 | -233 | 25 |
| -154 | 26 | -194 | 26 | -234 | 26 |
| -155 | 27 | -195 | 27 | -235 | 27 |
| -156 | 28 | -196 | 28 | -236 | 28 |
| -157 | 29 | -197 | 29 | -237 | 29 |
| -158 | 30 | -198 | 30 | -238 | 30 |
| -159 | 31 | -199 | 31 | -239 | 31 |
| -160 | 32 | -200 | 32 | -240 | 32 |
| -161 | 33 | -201 | 33 | -241 | 33 |
| -162 | 34 | -202 | 34 | -242 | 34 |
| -163 | 35 | -203 | 35 | -243 | 35 |
| -164 | 36 | -204 | 36 | -244 | 36 |
| -165 | 37 | -205 | 37 | -245 | 37 |
| -166 | 38 | -206 | 38 | -246 | 38 |
| -167 | 39 | -207 | 39 | -247 | 39 |
| -168 | 40 | -208 | 40 | -248 | 40 |

(1) Refers to numbers indicated in Appendix B.1.

(2) Refers to numbers shown in Appendix A.1.

(3) Refers to numbers shown in Appendix A.2.

Appendix B.3 Results of the Analysis of Variance of the Soils Data - 1985.

| Location Stat. | General Parameters | | | | Ions in Saturation Extract | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent Saturation | pH | Electrical Conductivity | SAR | $Na^{+}$ | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | $Cl^{-}$ | $SO_4^{--}$ |
| Floral | | | | | | | | | | |
| - MS treatments | 6.33 | 0.04 | 4.38 | 4.09 | 200309 | 360 | 61480 | 17.1 | 1840 | 2666250 |
| - MS errors | 29.53 | 0.04 | 4.05 | 3.84 | 157699 | 493 | 70600 | 93.2 | 3449 | 2779139 |
| - F | 0.21 | 1.0 | 1.08 | 1.07 | 1.27 | 0.73 | 0.87 | 0.19 | 0.53 | 0.96 |
| Buffer Lake | | | | | | | | | | |
| - MS treatments | 13.9 | 0.04 | 2.08 | 5.52 | 109046 | 3536 | 5416 | 1.29 | 4885 | 956509 |
| - MS errors | 31.1 | 0.02 | 4.78 | 9.27 | 230646 | 5739 | 19542 | 33.66 | 3119 | 2587856 |
| - F | 0.45 | 2.56 | 0.44 | 0.57 | 0.47 | 0.62 | 0.28 | 0.04 | 1.57 | 0.4 |
| Rosthern | | | | | | | | | | |
| - MS treatments | 4.4 | 0.007 | 1.11 | 4.97 | 58803 | 466 | 3003 | 142 | 628 | 47583 |
| - MS errors | 10.98 | 0.027 | 1.34 | 2.68 | 69774 | 377 | 7938 | 89.9 | 521 | 1172972 |
| - F | 0.4 | 0.3 | 0.83 | 1.85 | 1.23 | 1.2 | 0.38 | 1.6 | 1.2 | 0.04 |

# APPENDIX C

Appendix C.1 Plant Density Data.

| Location | Date | Species Seeded | Species Counted | Replicates | Number of Plants Per Metre of Row | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | L3 | C |
| Floral | June 13 | Slender wheatgrass | Total grasses | 1 | 11 | 4 | 2 | 13 |
| | | | | 2 | 25 | 16 | 14 | 16 |
| | | | | 3 | 2 | 11 | 17 | 31 |
| | | | | 4 | 8 | 10 | 7 | 2 |
| | | | | 5 | 8 | 19 | 20 | 13 |
| | | Western wheatgrass | Total grasses | 1 | 13 | 28 | 22 | 8 |
| | | | | 2 | 23 | 16 | 20 | 18 |
| | | | | 3 | 19 | 15 | 53 | 3 |
| | | | | 4 | 15 | 1 | 19 | 16 |
| | | | | 5 | 19 | 8 | 14 | 11 |
| | July 23 | Slender wheatgrass | Slender wheatgrass | 1 | 0 | 3 | 2 | 9 |
| | | | | 2 | 3 | 1 | 2 | 0 |
| | | | | 3 | 1 | 1 | 5 | 2 |
| | | | | 4 | 6 | 7 | 8 | 8 |
| | | | | 5 | 7 | 2 | 6 | 1 |
| | | Western wheatgrass | Western wheatgrass | 1 | 0 | 1 | 0 | 7 |
| | | | | 2 | 0 | 0 | 1 | 5 |
| | | | | 3 | 4 | 5 | 2 | 4 |
| | | | | 4 | 0 | 4 | 10 | 10 |
| | | | | 5 | 0 | 12 | 0 | 10 |
| Buffer Lake | July 3 | Slender wheatgrass | Total wheatgrasses | 1 | 2 | 2 | 3 | 2 |
| | | | | 2 | 2 | 3 | 3 | 6 |
| | | | | 3 | 2 | 1 | 1 | 2 |
| | | | | 4 | 2 | 1 | 1 | 2 |
| | | | | 5 | 2 | 1 | 2 | 2 |
| | | Sweetclover | Sweetclover | 1 | 2 | 1 | 1 | 1 |
| | | | | 2 | 2 | 1 | 1 | 1 |
| | | | | 3 | 1 | 1 | 0 | 3 |
| | | | | 4 | 2 | 1 | 1 | 3 |
| | | | | 5 | 6 | 2 | 4 | 1 |
| | July 22 | Slender wheatgrass | Total wheatgrasses | 1 | 1 | 2 | 4 | 1 |
| | | | | 2 | 6 | 0 | 3 | 5 |
| | | | | 3 | 4 | 2 | 3 | 4 |
| | | | | 4 | 2 | 1 | 2 | 2 |
| | | | | 5 | 1 | 3 | 1 | 2 |
| | | Sweetclover | Sweetclover | 1 | 1 | 2 | 3 | 3 |
| | | | | 2 | 2 | 0 | 2 | 1 |
| | | | | 3 | 1 | 1 | 3 | 3 |
| | | | | 4 | 3 | 1 | 10 | 4 |
| | | | | 5 | 6 | 4 | 6 | 4 |
| Rosthern | July 3 | Slender wheatgrass | Total wheatgrasses | 1 | 2 | 3 | 1 | 1 |
| | | | | 2 | 1 | 2 | 1 | 3 |
| | | | | 3 | 0 | 1 | 1 | 3 |
| | | | | 4 | 2 | 1 | 1 | 0 |
| | | | | 5 | 11 | 3 | 1 | 5 |

Appendix C.1 (Continued)

| Location | Date | Species Seeded | Species Counted | Replicates | Number of Plants Per Metre of Row | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | L3 | C |
| Rosthern | July 3 | Sweetclover | Sweetclover | 1 | 0 | 1 | 0 | 1 |
| | | | | 2 | 1 | 0 | 0 | 1 |
| | | | | 3 | 1 | 2 | 1 | 1 |
| | | | | 4 | 0 | 0 | 1 | 0 |
| | | | | 5 | 2 | 1 | 1 | 1 |
| | July 24 | Slender wheatgrass | Total wheatgrasses | 1 | 8 | 4 | 3 | 4 |
| | | | | 2 | 0 | 6 | 7 | 2 |
| | | | | 3 | 2 | 1 | 0 | 8 |
| | | | | 4 | 5 | 0 | 3 | 2 |
| | | | | 5 | 13 | 13 | 4 | 10 |
| | | Sweetclover | Sweetclover | 1 | 1 | 1 | 1 | 2 |
| | | | | 2 | 2 | 0 | 0 | 1 |
| | | | | 3 | 1 | 2 | 0 | 0 |
| | | | | 4 | 0 | 0 | 1 | 2 |
| | | | | 5 | 1 | 1 | 0 | 1 |

Appendix C.2 Results of the Analysis of Variance of the Plant Density Data.

| Location | Date | Species Seeded | Species Counted | MS Treatments | MS Errors | F |
|---|---|---|---|---|---|---|
| Floral | June 13 | Slender wheatgrass | Total grasses | 16.05 | 67.55 | 0.24 |
| | | Western wheatgrass | Total grasses | 199.65 | 99.13 | 2.01 |
| | July 23 | Slender wheatgrass | Slender wheatgrass | 3.00 | 9.95 | 0.30 |
| | | Western wheatgrass | Western wheatgrass | 37.25 | 12.75 | 2.92 |
| Buffer Lake | July 3 | Slender wheatgrass | Total wheatgrasses | 1.27 | 1.25 | 1.01 |
| | | Sweetclover | Sweetclover | 1.92 | 1.88 | 1.02 |
| | July 22 | Slender wheatgrass | Total wheatgrasses | 1.65 | 2.50 | 0.66 |
| | | Sweetclover | Sweetclover | 8.93 | 4.7 | 1.90 |
| Rosthern | July 3 | Slender wheatgrass | Total wheatgrasses | 4.18 | 6.13 | 0.68 |
| | | Sweetclover | Sweetclover | 0.05 | 0.48 | 0.11 |
| | July 24 | Slender wheatgrass | Total wheatgrasses | 4.6 | 17.15 | 0.27 |
| | | Sweetclover | Sweetclover | 0.58 | 0.55 | 1.06 |